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Petricoin, Jr.

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(54) **SCANNING SECURITY DETECTOR**

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(52) **U.S. Cl.**
USPC **340/555**; 340/541; 340/557

(58) **Field of Classification Search**
USPC 340/555–557
See application file for complete search history.

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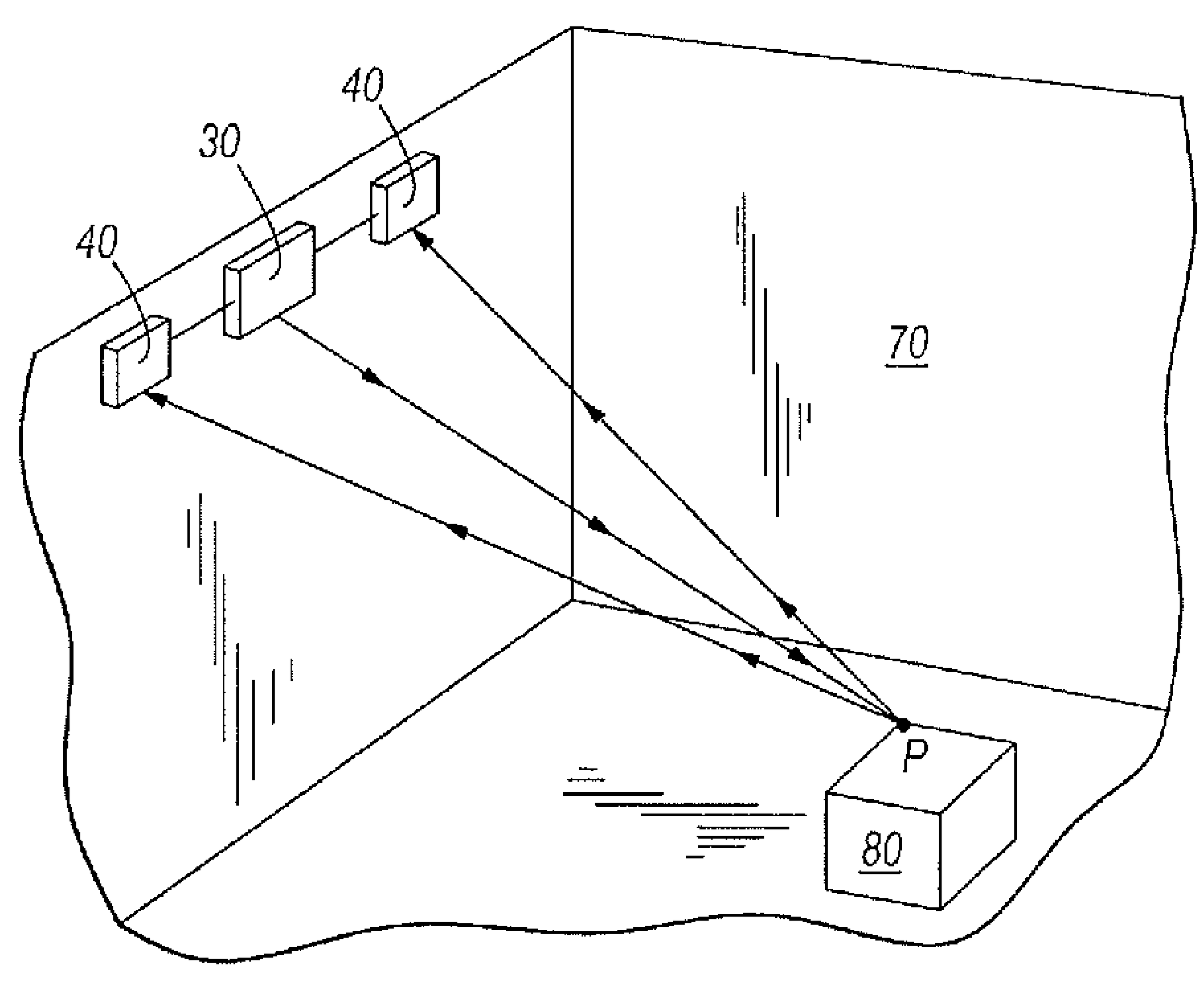
(57) **ABSTRACT**

A method of identifying a potential security threat in a space. A first scan of the space is performed during a first time interval by illuminating at least a portion of the space with energy from an energy source at an illumination angle, such that the energy is reflected from a surface in the space. An incident angle of the reflected energy is detected with a detector located at a known distance from the energy source and a distance from the surface to the energy source is calculated based on the incident angle. The steps are repeated for a plurality of different locations in the space. A first map of the space is generated from the first scan, and a second map is generated from a second scan of the area. The maps are compared to determine a change in the space and to determine if a potential security threat is present.

11 Claims, 6 Drawing Sheets



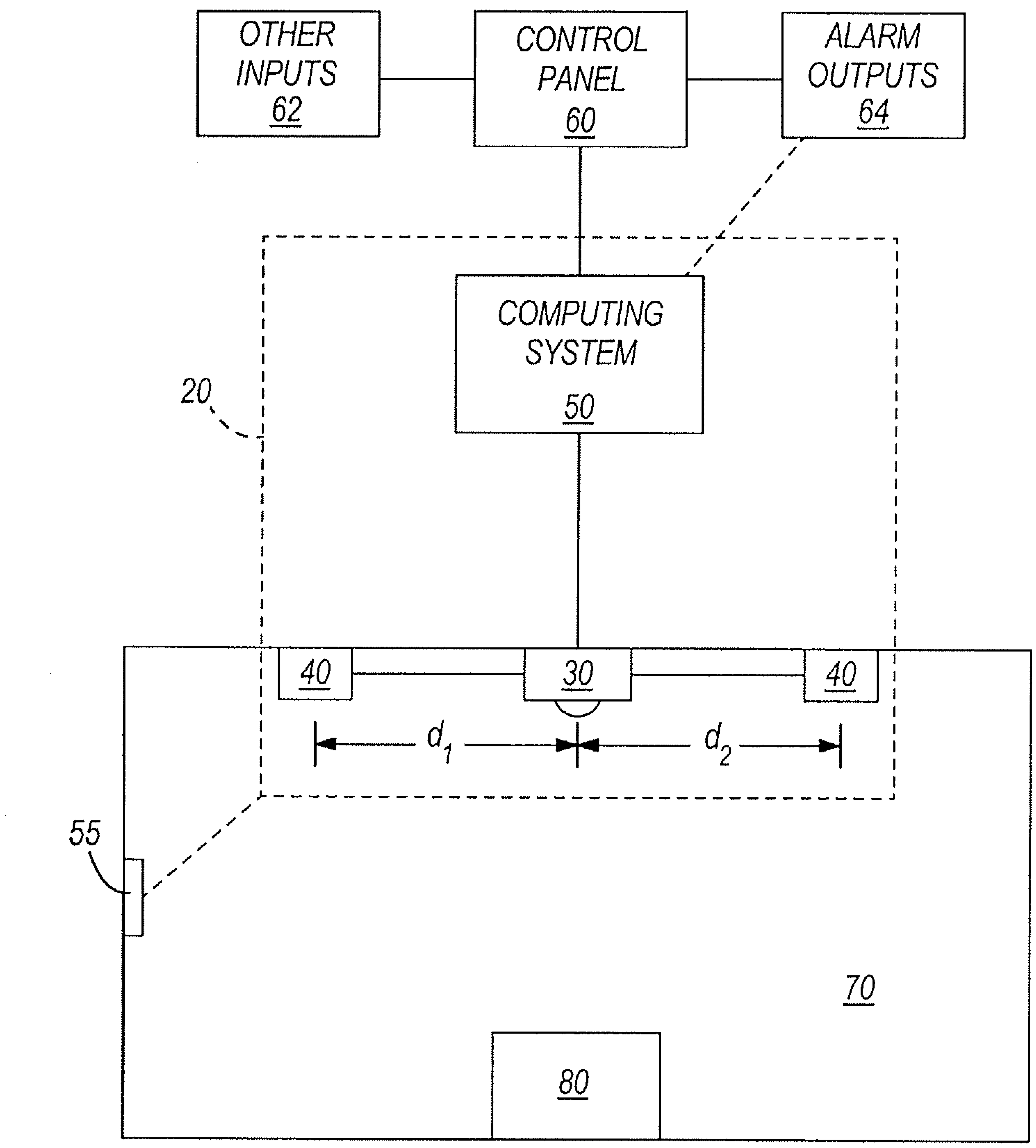

OTHER INPUTS 62
CONTROL PANEL 60
ALARM OUTPUTS 64
COMPUTING SYSTEM 50
20
40
30
40
d1
d2
55
70
80

FIG. 1

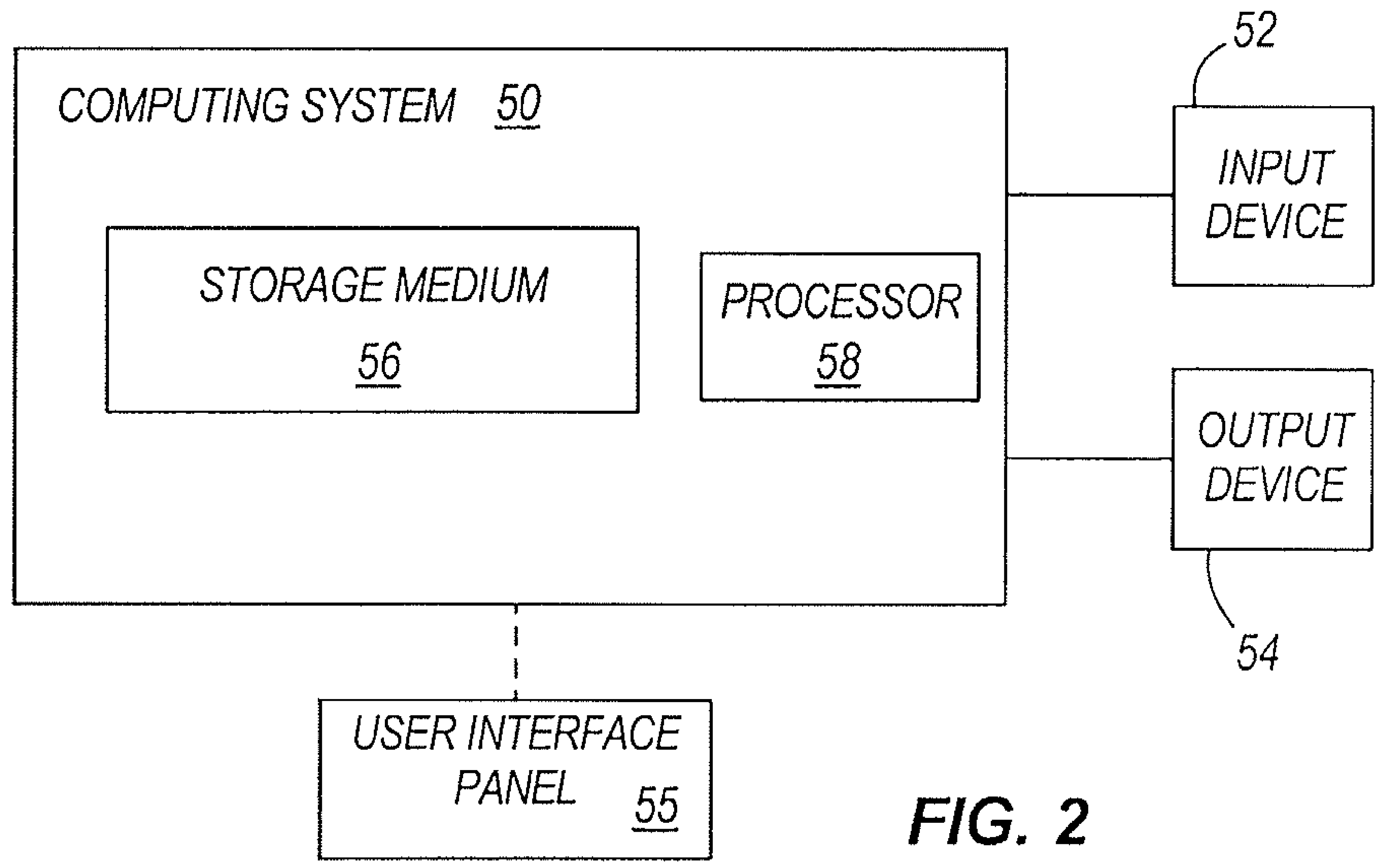

COMPUTING SYSTEM 50
STORAGE MEDIUM 56
PROCESSOR 58
INPUT DEVICE
52
OUTPUT DEVICE
54
USER INTERFACE PANEL 55

FIG. 2

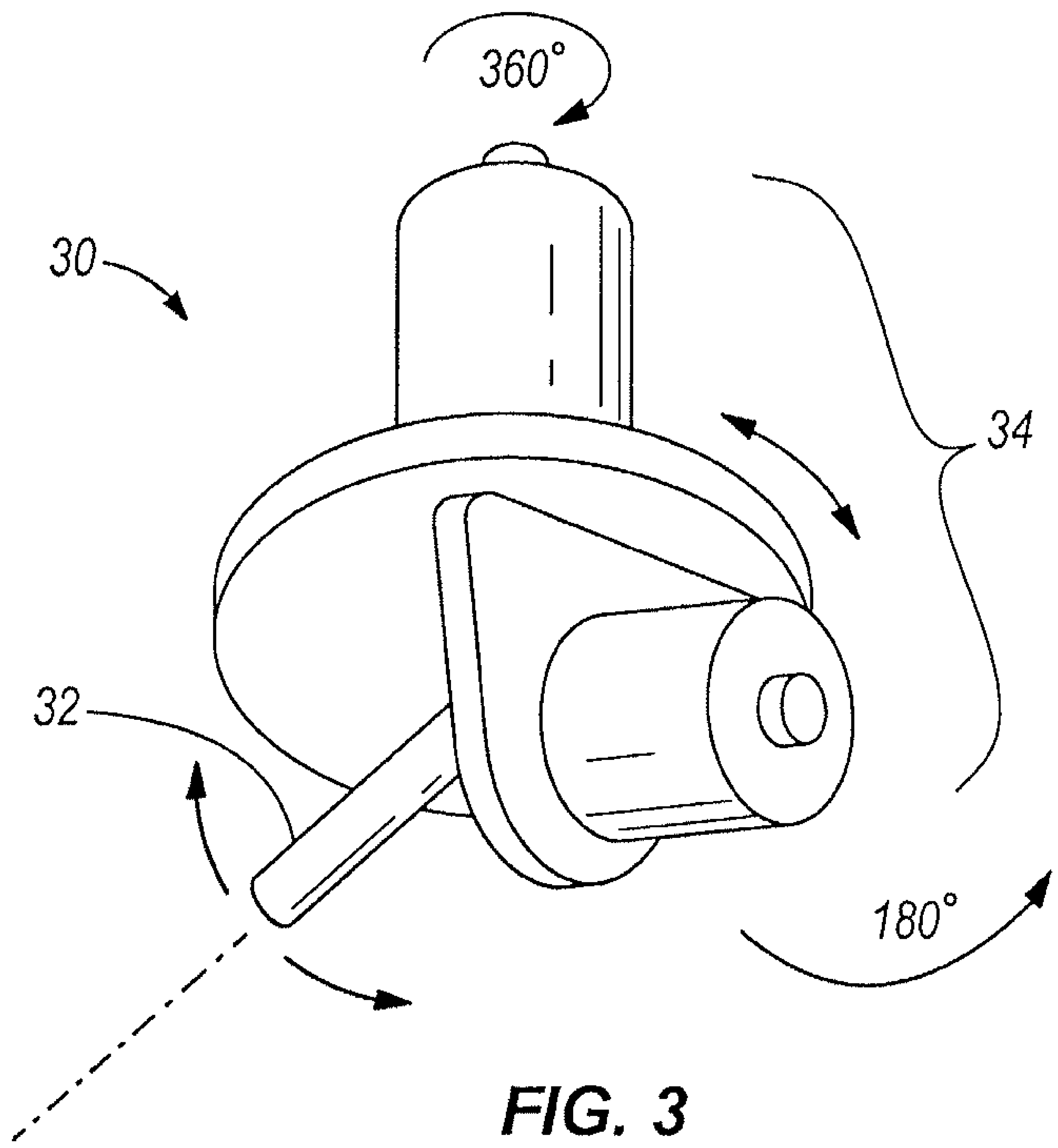

360°
30
34
32
180°

FIG. 3

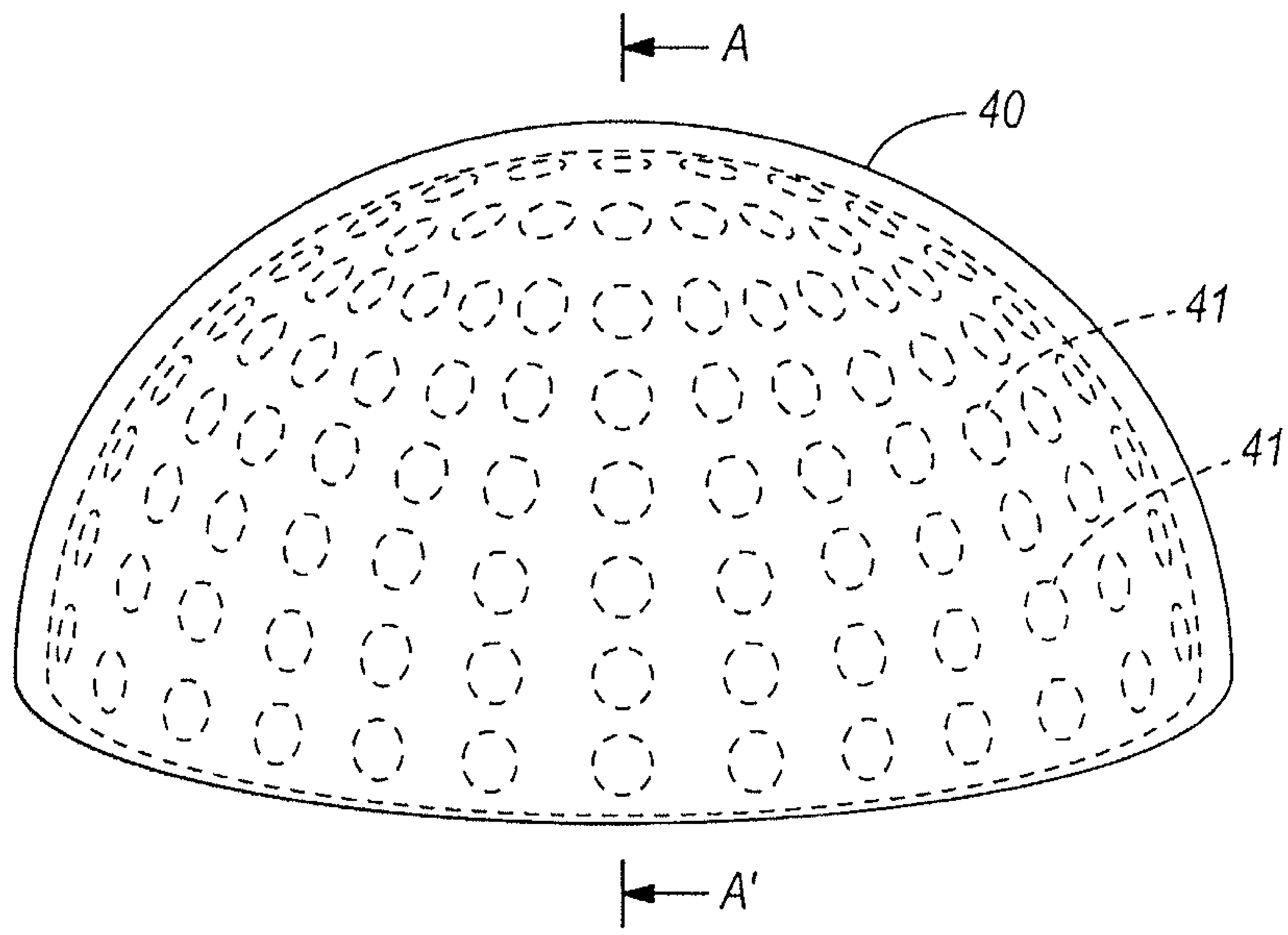


FIG. 4A

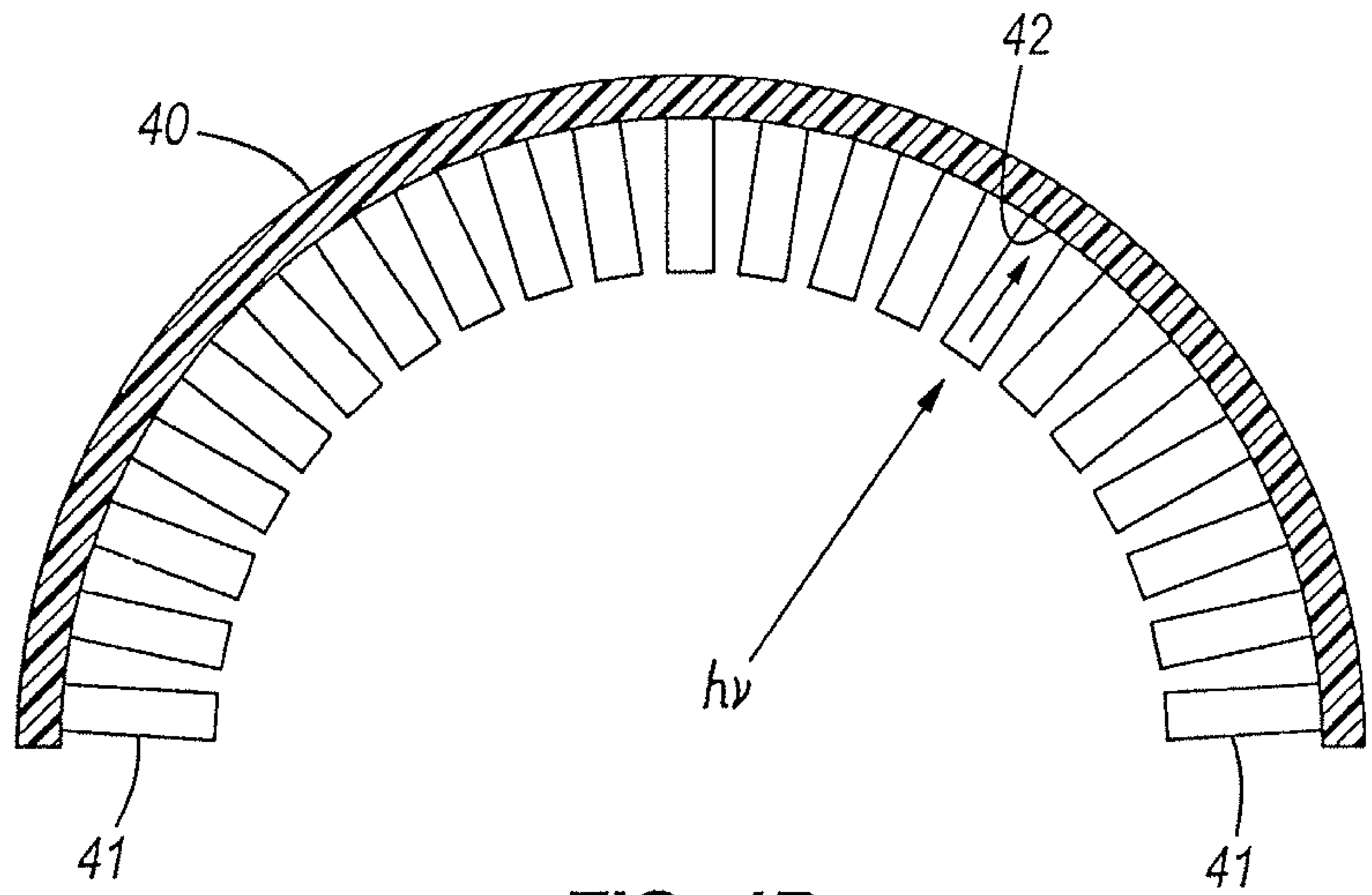


FIG. 4B

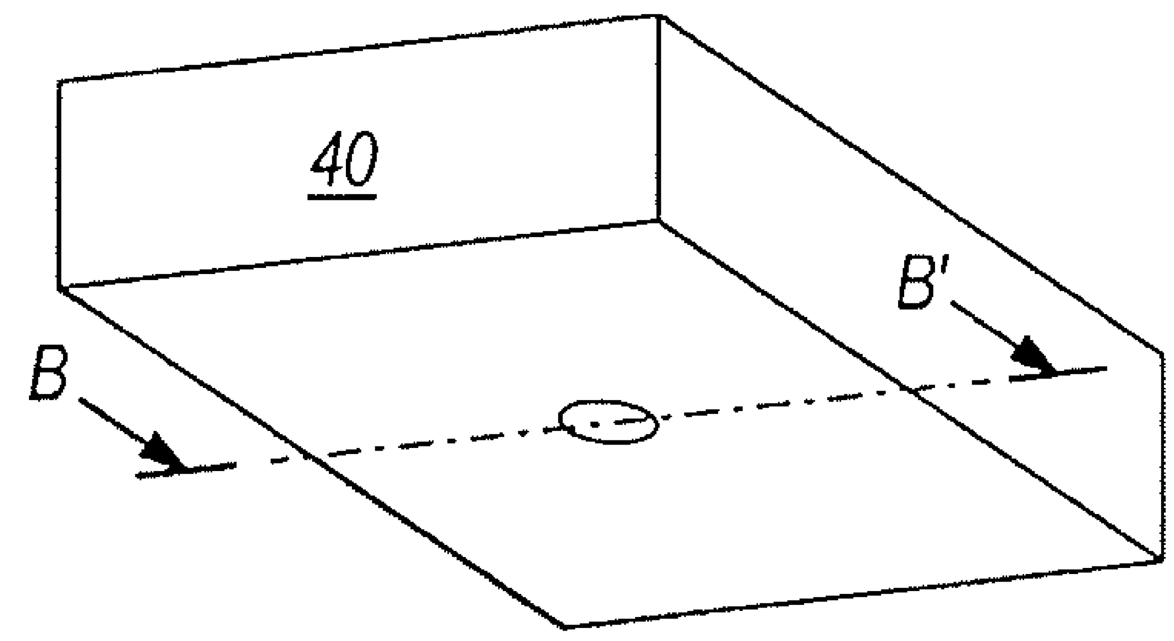


FIG. 5A

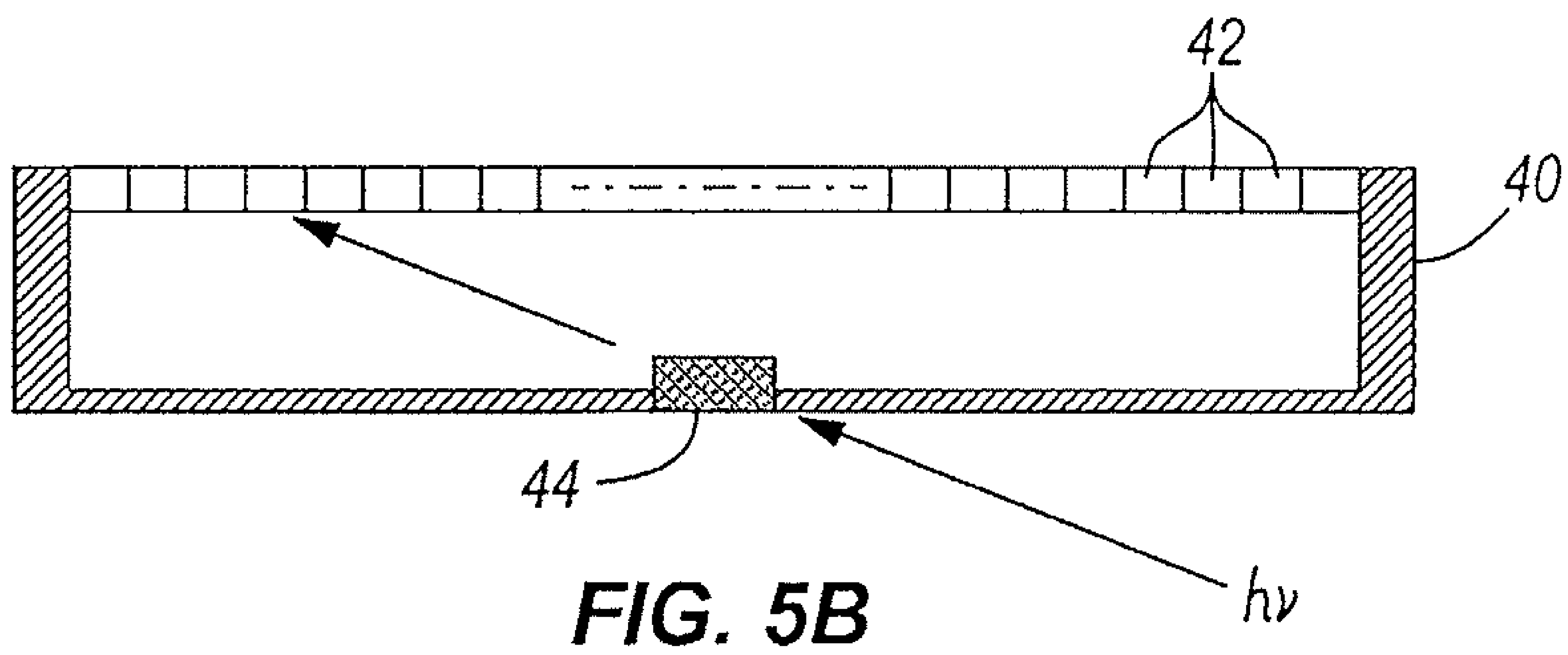


FIG. 5B

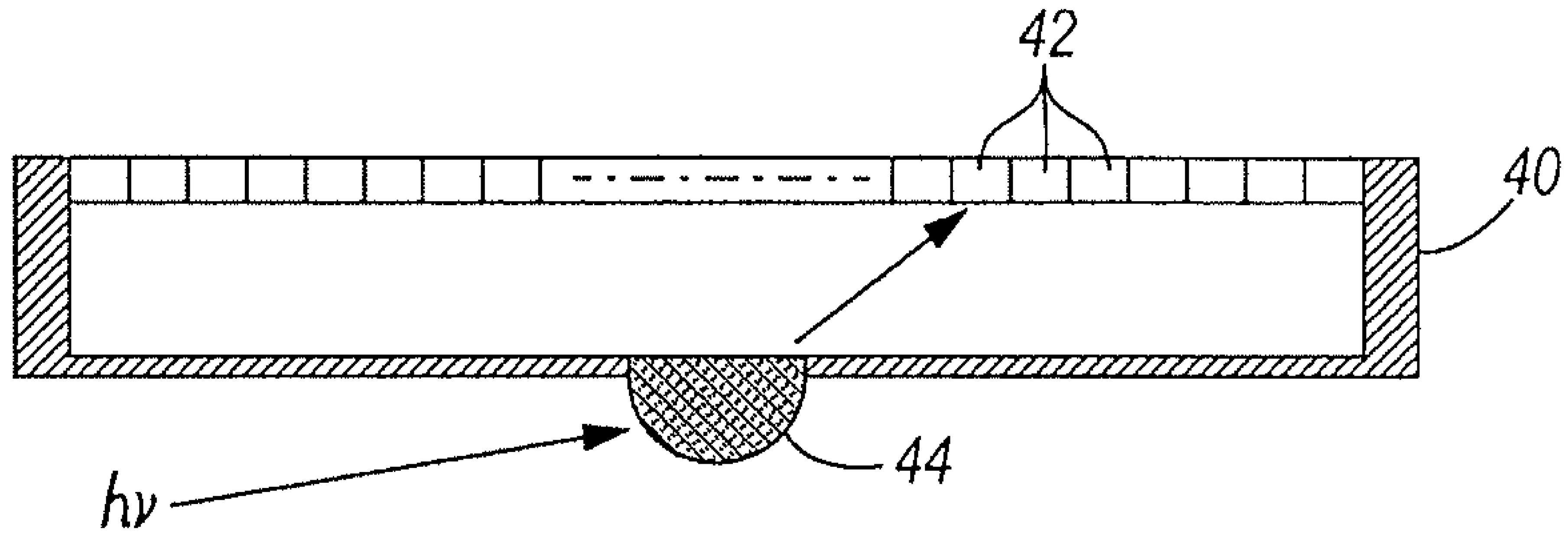


FIG. 5C

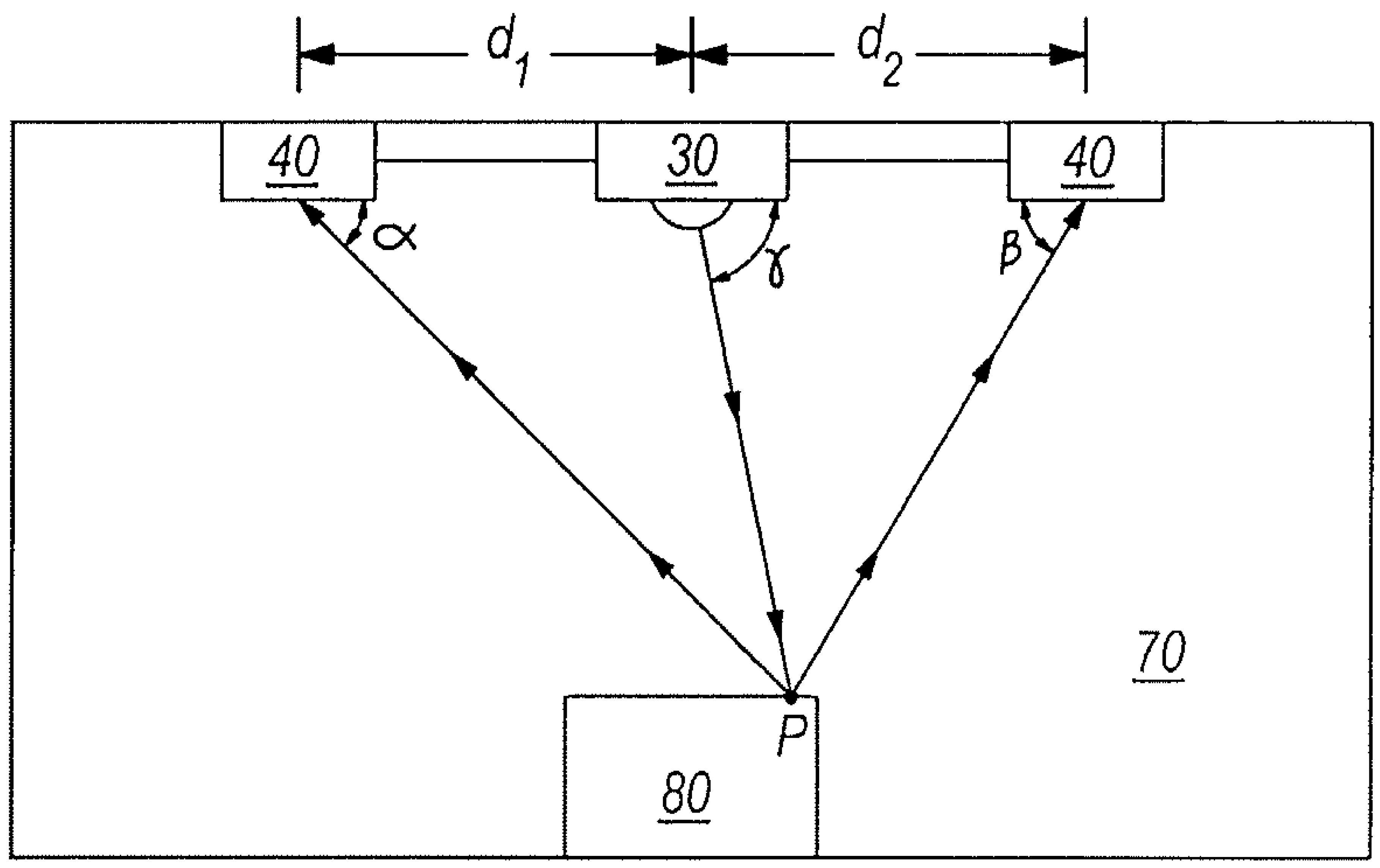


FIG. 6

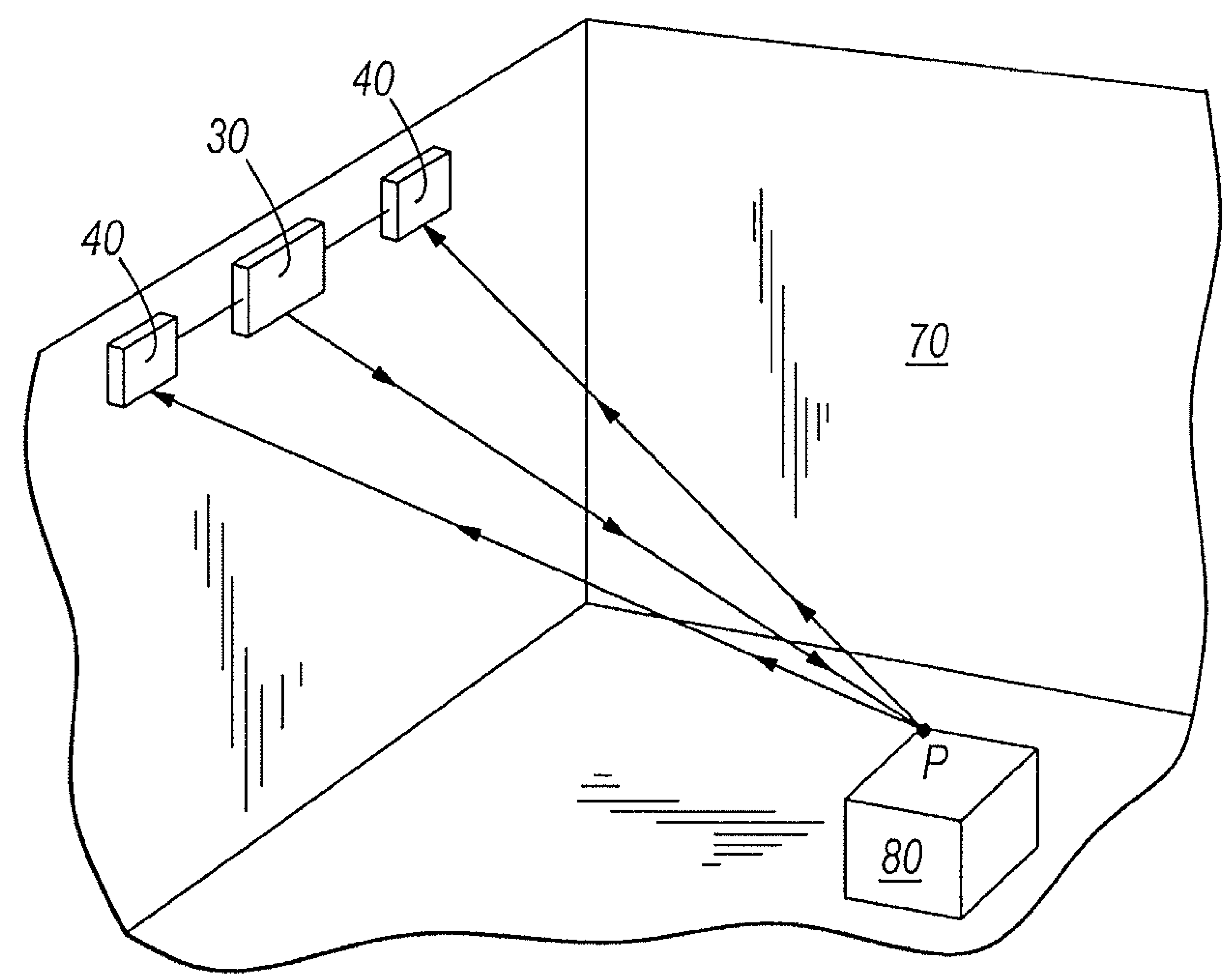


FIG. 7

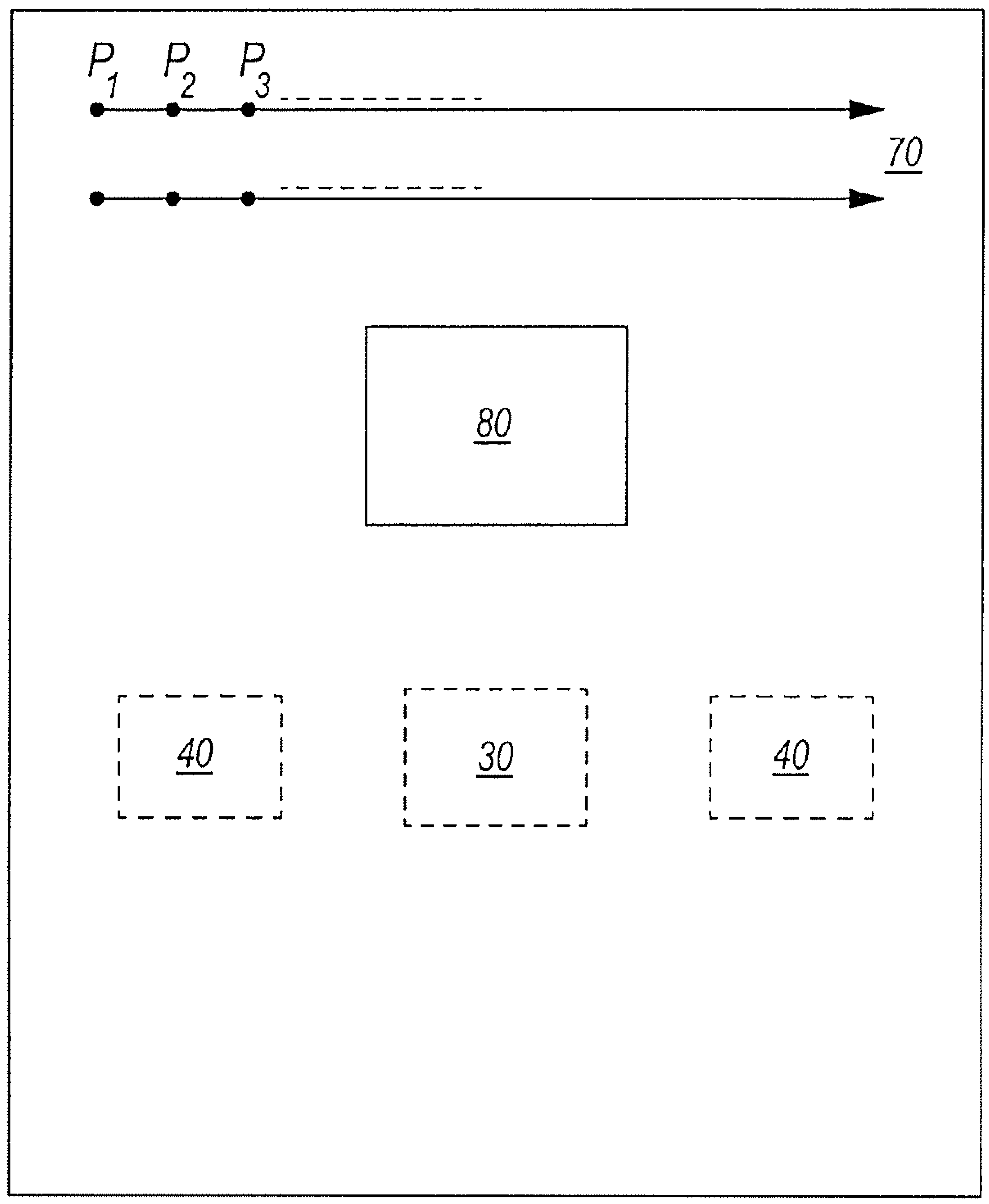


FIG. 8

SCANNING SECURITY DETECTOR

BACKGROUND

1. Field of Invention

The present invention relates to security systems, in particular to a scanning security system that captures volumetric images of a space over time and analyzes the images to identify potential security threats.

2. Related Art

Many security systems employ devices such as motion sensors and light beams as simple and inexpensive mechanisms to determine whether there is a potential security threat in a space. However, these relatively unsophisticated systems are not effective at distinguishing false positives (i.e. small animals, waving plants or balloons) from true security threats. In addition, these systems can sometimes be defeated by avoidance of the sensor beams or by covering the detectors.

SUMMARY OF THE INVENTION

In one aspect, the invention is a method of identifying a potential security threat in a space, including collecting a first scan of the space during a first time interval. Collecting a first scan includes (i) illuminating at least a portion of the space with energy from an energy source at an illumination angle, such that the energy is reflected from a surface in the space; (ii) detecting an incident angle of the reflected energy with a detector disposed at a known distance from the energy source; (iii) calculating a distance from the surface to the energy source based on the incident angle; (iv) repeating steps (i)-(iii) for a plurality of different locations in the space; and (v) generating a first map of the space for the first time interval. The method includes collecting a second scan of the space at a second time interval, comprising repeating steps (i)-(v) above during the second time interval to generate a second map of the space; comparing the first map to the second map to determine a change in the space; and determining if a potential security threat is present based on the change in the space.

In another aspect, the invention is a method of distinguishing false positives from threats in a space, including collecting a first scan of the space during a first time interval. Collecting a first scan includes (i) illuminating at least a portion of the space with an energy from an energy source such that the energy is reflected from a surface in the space; (ii) detecting the incident angle of the reflected energy with a detector disposed at a known distance from the energy source; (iii) calculating a distance from the surface to the energy source using triangulation; (iv) repeating steps (i)-(iii) for a plurality of portions of the space; and (v) generating a first map of the space for the first time interval. The method further includes collecting a second scan of the space during a second time interval, comprising repeating steps (i)-(v) above during the second time interval to generate a second map of the space and comparing the first map to the second map to determine a change in the space. The method also includes identifying a potential security threat based on the change in the space and determining if the potential security threat is a false positive based on at least one of a rate of movement, a height, and a location of the threat within the space.

In still another aspect, the invention is a scanning security system, the security system including a transmitter, a detector, and a computing system. The transmitter includes an energy source and a scanning assembly. The detector is configured to detect a direction of energy impinging thereon. The computing system includes a processor and a storage medium. The computing system is configured to collect a first scan of a space during a first time interval. Collecting a first scan includes (i) illuminating at least a portion of the space with energy from the energy source at an illumination angle, such that the energy is reflected from a surface in the space; (ii) detecting an incident angle of the reflected energy with the detector disposed at a known distance from the energy source; (iii) calculating a distance from the surface to the energy source based on the incident angle; (iv) repeating steps (i)-(iii) for a plurality of different locations in the space; and (v) generating a first map of the space for the first time interval. The computing system is further configured to collect a second scan of the space at a second time interval, wherein collecting a second scan includes repeating steps (i)-(v) above during the second time interval to generate a second map of the space. The computing system is also configured to compare the first map to the second map to determine a change in the space and determine if a potential security threat is present based on the change in the space.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the accompanying drawings in which:

FIG. **1** is a schematic diagram of a scanning security system;

FIG. **2** is a schematic diagram of a computing system as is used with the scanning security system;

FIG. **3** shows a movable energy transmitter for use with the scanning security system;

FIG. **4**A shows a detector for use with the scanning security system;

FIG. **4**B shows a cross-section along A-A' of the detector of FIG. **4**A;

FIG. **5**A shows another detector for use with the scanning security system;

FIG. **5**B shows a cross-section along B-B' of the detector of FIG. **5**A;

FIG. **5**C shows a cross-section along B-B' of an alternative construction of the detector of FIG. **5**A;

FIG. **6** is a diagram of energy transmission, reflection, and detection for a scanning security system;

FIG. **7** is a diagram of energy transmission, reflection, and detection for an alternative construction of a scanning security system; and

FIG. **8** is a top view of a space and a scanning pattern for the space for a scanning security system.

DETAILED DESCRIPTION OF THE INVENTION

Before any constructions of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other constructions and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

A security system **20** according to one construction of the invention is shown in FIG. **1**. The system **20** includes a transmitter **30**, one or more detectors **40**, and a computer or computing system **50**. The detectors **40** are separated from each other and spaced distances d1 and d2 from the transmitter. The detectors are electrically connected to the transmitter **30** and the transmitter **30** is electrically connected to the computing system **50**. Thus, information from the detectors **40** is communicated to the computing system **50**. In one construction, the system **20** communicates with a control panel **60**. The control panel **60** receives security threat information from the system **20** and may also receive information from other input sources **62**, including other security devices (e.g., door sensors, motion sensors, beam sensors), safety-related devices (e.g. smoke detectors, fire alarms, etc.), or various environmental sensors (e.g. temperature, water, or light sensors). The control panel **60** in turn may be coupled to various alarm-type outputs **64** such as lights, audible alarms (e.g. a mechanical bell or siren, or an electronic alarm), or a signal to a remote location such as a police station, a private security firm, or an individual (a homeowner) can be directly notified electronically (e.g. through a pager, cell phone, or other portable electronic device, an automatically-generated email, or other electronic means). Alternatively, the system **20** may be directly coupled to the alarm-type outputs **64** without an intervening control panel **60** (FIG. **1**).

The computing system **50** may be integrated into the transmitter **30** or may be a separate component. The computing system **50** includes an input device **52**, an output device **54**, a storage medium **56**, and a processor **58** (FIG. **2**). Possible input devices **52** include a keyboard, a computer mouse, a touch screen, and the like. Output devices **54** include a cathode-ray tube (CRT) computer monitor, a liquid-crystal display (LCD) computer monitor, a light-emitting diode (LED) display, and the like. Storage media **56** include various types of memory such as a hard disk, RAM, flash memory, and other magnetic, optical, physical, or electronic memory devices. The processor **58** is a computer processor suitable for performing calculations and directing other functions for performing input, output, calculation, and display of data in the disclosed calculator.

Input and output functions may be included on a separate device that is remote from the rest of the system **20**, instead of or in addition to any other input device **52** or output device **54**. For example, a user interface panel **55** may be mounted on a wall in the space **70** along with the other components of the system **20**, or alternatively the user interface panel **55** may be mounted in a remote location so that the system **20** can be armed or disarmed without entering or leaving the space **70** (FIG. **2**). In another construction, the user interface panel **55** is a portable remote control. In each case, the user interface panel **55** may be hard-wired to the system **20** or may communicate with the system via a wireless connection, for example using radio frequency, infrared, ultrasonic, or other methods of wireless communication. The appropriate receiver for the wireless communications may be located either as a standalone component or may be incorporated into a component of the system **20**, such as the computing system **50**, the transmitter **30**, or the detectors **40**.

The computing system **50** may be a stand-alone component or may be integrated into the transmitter **30**. If the computing system **50** is a separate component from the transmitter **30**, the transmitter **30** and computing system **50** may be wired together or may communicate wirelessly (e.g. using radio-frequency, infrared, or other wireless signals). Similarly, the detector(s) **40** may communicate with the computing system **50** and/or the transmitter **30** via wired or wireless connections. Each of the components of the system **20** may be powered by a battery (disposable or rechargeable) or other portable power supply, or an A/C power source. In one construction, power can be provided by both the A/C source as well as a battery, such that the system **20** operates from A/C power at times but can also be operated solely on battery power for periods of time, e.g., in event of a power failure. The computing system **50** also encompasses elements that may be incorporated into other elements of the system **20**, for example logic and memory elements may be incorporated into the transmitter **30**, the detectors **40**, or the user interface panel **55**.

The transmitter **30** is a device that can deliver a focused beam of energy to points in the space **70**. The energy should be capable of being reflected from the objects **80** of interest in the space **70**. The transmitter **30** comprises an energy source **32** and a scanning assembly **34** (FIG. **3**). Possible types of energy include light, including ultraviolet, infrared, and visible light; ultrasonic; and microwave. The energy may be focused into a beam using optical (in the case of light), electronic, or other appropriate focusing elements. Alternatively, the energy source **32** may be a laser (e.g. a infrared laser) or other focused energy source. The energy may be emitted continuously or may be intermittent. To produce an intermittent beam of energy, the energy source **32** may be switched on and off, or a shutter device may be placed in the path of the beam. In one construction a pulsed laser is used as the energy source **32** to produce an intermittent energy beam.

In some constructions, the energy source **32** emits energy having an identifiable signature, so that reflected energy collected by the detectors **40** can be distinguished from background emissions, and also so that an intruder cannot defeat the system by deliberately increasing the background levels of the energy, e.g. by shining an infrared source in the space **70**. In one construction, the signature comprises a modulated or pulsed laser signature of a particular frequency (e.g., 30 kHz) and wavelength (e.g., an infrared wavelength) that is distinct from background energy levels. In such constructions, appropriate detectors **40** are provided which not only are suitable for the particular type of energy that is emitted by the energy source **32**, but which are capable of identifying the signature (e.g., the detectors **40** may include a lock-in amplifier set for the appropriate frequency).

The scanning assembly **34** moves the energy source **32** in a controlled manner so that the energy beam can be scanned throughout the space **70**. In one construction, the scanning assembly **34** comprises a rotating base on which the energy source **32** is pivotably mounted (FIG. **3**). The rotation of the base and the pivoting of the energy source **32** relative to the base may be controlled by stepper motors, so that the energy source **32** can be rotated 360° and pivoted 180° in precise increments, allowing the energy source **32** to be aimed any point in the space **70** that is at or below the height of the transmitter **30**. In some constructions, the actual position of the energy source **32** is determined (e.g., using optical encoders) and this position is transmitted to the computing system **50** to be used in calculating positions of objects. In other constructions, the positions of the energy source **32** are calculated based on movement instructions sent by the computing system **50** to the scanning assembly **34**, i.e., to the stepper motors or other positioning devices of the scanning assembly **34**.

Suitable detectors **40** are chosen that are capable of recognizing the energy that is emitted from the transmitter **30** against whatever background levels of energy are present in the space **70**. The detectors **40** may comprise one or more photomultipliers, photodiodes, CCDs, optical elements, or other suitable device for detecting the particular energy that is emitted by the transmitter **30**. The detectors **40** may also include energy- and wavelength-selective filters so that only the energy that is emitted by the transmitter **30** is permitted to reach the detectors **40**. The detectors **40** convert the detected energy to an electronic signal that is transmitted to the computing system **50**. The detectors **40** also transmit information to the computing system **50**, information which indicates the angle at which the detected energy impinged on the detector **40**.

In one construction, the detector **40** comprises a hemispherically-arranged collection of tubes **41**, each having an individual energy detection element **42** at the bottom thereof (FIGS. **4**A, **4**B). In one construction the tubes **41** are attached to a hemispherical element made of metal, plastic, or other suitable material. The hemispherical element may be a flat surface (e.g. half of a hollow sphere) or it may be a mesh, grid, lattice, or other discontinuous structure. The tubes **41** are preferably opaque throughout and non-reflective on the insides thereof. At least one end of each tube **41** permits energy to pass therethrough (e.g. the tube **41** is open or has an appropriate filter, glass, or optical element on the end to permit energy to pass into the tube). The detection elements **42** are inside the tubes **41**, for example at the bottoms thereof. Given that the detection elements **42** are at the bottoms of relatively narrow, opaque, and non-reflective tubes **41**, only the energy that is reflected from a particular direction (generally the energy that is on a course that is parallel to the sides of the tube **41**) reaches the detection element **42**. Thus, knowledge of the position of the tube **41** and detection element **42** that received the reflected energy (or the highest level of reflected energy) indicates the angle at which the reflected energy impinged on the detector **40**. The impingement angles corresponding to each tube **41** can be determined at the time of manufacture and/or based on a calibration procedure performed on the system **20** after installation.

In another construction, the detector **40** comprises a plurality of individual detection elements **42** arranged in a linear or two-dimensional array, where the reflected energy goes through a pinhole, lens, or prism **44** before impinging on one or more of the individual detection elements **42** (FIGS. **5**A, **5**B, **5**C). The pinhole, lens, or prism **44** allows energy to penetrate the detector housing while the remainder of the housing blocks the energy, thus focusing the energy on one or a small number of detection elements **42**. If element **44** is a lens or prism, the incoming energy may be gathered from a relatively wide area and focus it into a smaller cone that can be projected onto the array of detection elements **42**. For example, if a fisheye lens is employed for element **44**, light may be collected from a complete hemispherical region (FIG. **5**C). Similarly, if a prism is employed for element **44**, incident energy is directed to a particular detection element **42** based on the angle of incidence and the structure of the prism **44**. The angle at which the reflected energy has impinged on the detector **40** is determined using information regarding the position of the array of detection elements **42** as well as information regarding which of the detection element(s) **42** received the reflected energy (or the highest level of reflected energy). For any of the variations on the system **20** described herein, initial calibration of the spatial relationship between the position of the transmitter **30** and the response of the detectors **40** can be performed under controlled conditions.

In one construction, the detectors **40** are fixedly mounted, e.g., to the ceiling of a room. In this case, the detectors **40** are capable of receiving reflected energy from any location within the space **70**. In another construction, the detectors **40** have a more limited zone of reception, but the array of detection elements **42** is aimed in the same direction as the transmitter **30**. In the latter case, subsequent calculation of the incident angle of reflected energy takes into account the direction of the array of detection elements **42**.

The information regarding the direction at which the energy impinges on the detector **40** can include the angle of the incoming energy relative to the horizontal as well as the direction of the incoming energy with respect to a vertical axis.

The detectors **40** are located at a known distance apart and in the vicinity of the transmitter **30**. Although the exemplary system **20** presented in the text and figures depicts two detectors **40**, the system **20** can also work with one, three, or more detectors. In a construction of the system **20** having a single detector, the angle γ at which the transmitter **30** emits energy is used along with the angle β at which the detector **40** receives the reflected energy and the distance d_2 between the transmitter **30** and the detector **40** to calculate the three-dimensional location of point P on the object **80** (FIG. **6**). When two or more detectors **40** are used, the distance d_1+d_2 between the detectors **40** may be used, along with the angles α and β of the incident energy impinging on the detectors **40** (FIG. **6**). When the third dimension is considered, an additional angle of incident energy is factored in for each detector **40** and the three-dimensional location of reflective point P is determined using known triangulation methods. The location of point P can be expressed in three-dimensional (x, y, z) coordinates, polar coordinates (r, θ), or other appropriate coordinate system. The point of reference for any of the coordinate systems can be made relative to any convenient point, for example the location of the transmitter **30** or in a remote corner of the space **70**.

For reference, the distance of the transmitter **30** and detectors **40** from the bottom of the space **70** can be recorded. In one construction, the space **70** is a room and the transmitter **30** and detectors **40** are at the same distance from the bottom of the space **70**, corresponding approximately to the distance from the floor to the ceiling of the room, less the thickness of the transmitter **30** and detectors **40**. This distance can be entered by having a user simply measure the distance and record it manually using a user interface. Alternatively, the system **20** can calculate the distance to the bottom of the space **70** (e.g., the floor of a room), provided that the user indicates which location to use. For example, the user may remove all objects from directly under the transmitter **30**, instruct the system **20** to calibrate the distance to the floor, and appropriate readings would be taken to determine the distance of the space immediately below the transmitter **30**, which would be stored and thereafter used as the floor-to-ceiling height. Other reference points could also be calculated and other methods of calibration could be used as well.

Using the measurement of the distance from the bottom of the space **70**, the system **20** can then determine the height of an object in the space **70**. Information regarding the height may then be used as part of an analysis to distinguish false positive readings from actual security threats. For example, if a moving object is detected and the object is less than two feet tall, then the object might be dismissed as a false positive if it is known that there are small pets (e.g., dogs or cats) in the space **70**.

If a single detector **40** is employed, the distance between the detector **40** and the transmitter **30** is recorded in the system **20**. In constructions of the system **20** employing two or more detectors **40**, the distances between each detector **40** and the transmitter **30** are recorded in the system **20**. Thus, if a signal is received from only one detector **40** (e.g., if a detector is broken, loses its connection, or is obstructed) the system **20** can still perform triangulation calculations based on the data from the single detector **40**, the angle at which the beam of energy is emitted from the transmitter **30**, and the distance between the transmitter **30** and the detector **40** (FIG. **6**).

The distances between the one or more detectors **40** and the transmitter **30** can be entered into the system **20** in several ways. In one construction, the detectors **40** and the transmitter **30** are fixedly mounted to one another at known distances at the time of manufacture, or these preset distances are determined by factory-made connecting elements. The preset distances are programmed into the computing system **50**, also at the time of manufacture, so that the computing system **50** uses these values when performing triangulation calculations. In another construction, the distances between the one or more detectors **40** and the transmitter **30** are measured after the system **20** is installed and these measurements are entered into the computing system **50**. The distances between the transmitter **30** and the detectors **40** can be set to optimize coverage of the space **70** as well as accuracy of the scanning. Locations of the transmitter **30** and/or the detectors **40**, and distances therebetween, can also be reset after the initial installation to account for changes in the space **70**, including changes in the locations of objects **80**.

The transmitter **30** and detectors **40** can be mounted horizontally within the space **70**, e.g., on a ceiling in a room (FIGS. **1**, **6**). Alternatively, the transmitter **30** and detectors **40** may be mounted vertically, e.g., on a wall, in either case typically in an elevated position relative to the objects **80** within the space **70** to allow the energy beam to probe the space **70** and to have sufficient open area to be reflected back to the detectors **40** reliably (FIG. **7**). In some constructions, multiple transmitters **30** and detectors **40** are mounted in a space **70**. For example, multiple transmitters and detectors are used if the space **70** is large or has large objects **80** that obstruct parts of the space **70**, or if the space **70** has a complex shape that cannot be probed by a single transmitter **30**.

Using the above-described components, the system **20** generates three-dimensional maps of a space **70** (e.g., an interior room or an outdoor space) which may include one or more objects **80** therein (FIG. **1**). The maps are generated by the processor **58** of the computing system **50** and stored in the storage medium **56**, and may also be transmitted to the output device **54** for viewing or other use. The system **20** generates multiple maps over time and compares the information contained in the maps between time points to determine if there are security threats.

To generate a single three-dimensional map of the space **70**, the system **20** collects three-dimensional position data from a series of points throughout the space **70**. To collect a single position location, the transmitter **30** transmits a beam of energy into the space **70** and the detectors **40** detect the energy that is reflected back (FIG. **6**). In one construction, the energy source **32** is moved incrementally and its motion may be paused briefly while the detectors **40** collect energy that is reflected from the space **70**, including from objects **80** within the space **70**. The detectors **40** sense the incident angle of the reflected energy, and information regarding the angle and/or intensity of detected energy is transmitted to the computing system **50**.

In some cases, more than one detection element **42** of a particular detector **40** records a reflected energy signal, in which case the computing system **50** may simply record the angle corresponding to the detection element **42** having the highest level of signal. Alternatively, the system **50** may interpolate an incident angle corresponding to a location between several different detection elements **42** that detected a significant level of energy. Based on the distance between the detectors **40** and the angles at which the reflected energy reached each detector **40**, the computing system **50** uses triangulation methods to calculate the location in three-dimensional space from which the energy was reflected. Alternatively, the triangulation calculations may be based on the incident angle data from one detector **40** along with the angle at which the energy beam was transmitted into the space **70** and the distance between the transmitter **30** and the detector **40**.

By repeating the above procedure for a plurality of points throughout the space **70**, a complete three-dimensional map is generated. In one construction, the scanning assembly **34** moves the energy source **32** in a raster-scanning motion, i.e., a series of parallel lines are scanned, moving across the room or other space **70** to determine positions of points P_1, P_2, P_3, etc. (FIG. **8**). In other constructions, a particular subregion of interest may be scanned repeatedly, e.g., due to movement of objects within the particular area. In one particular construction, the entire space **70** is scanned repeatedly

The space **70** may be completely scanned at a lower temporal or spatial resolution until a significant difference is noted between two subsequent scans, indicating a possible security threat. Subsequent scanning can then be performed at higher spatial and/or temporal resolutions, either throughout the entire space **70** or only within the particular region where the difference was observed.

In various constructions, the space **70** is completely scanned at time intervals of about once in 250 milliseconds, about once per second, about once per minute, about once every five minutes, about once every ten minutes, or about once per hour. Shorter or longer time intervals are also possible. The number of points and lines per scan will also be varied based on factors including the size of the space **70** or a subregion thereof to be scanned; the response time of the equipment that is used; and the time required to obtain a sufficiently clear signal. In some constructions, the system **20** begins a subsequent scan as soon as the previous scan is complete. In other constructions, the system **20** waits for a delay interval before beginning the next scan. In still other constructions, the system **20** begins each scan when a predetermined amount of time has elapsed, e.g., a new scan is started every 30 seconds.

In one construction, the scanned points are collected at spatial intervals determined by uniform changes in the angle of the energy source **32**. When the energy source **32** scans regions of the space **70** that are distant from the transmitter **30**, moving the energy source in uniform increments leads to a non-uniform probing of the space **70**. In another construction, the energy source **32** is moved at non-uniform angle increments that produce a substantially uniform linear spacing between subsequent points. In still other constructions, various other uniform or non-uniform scanning procedures may be used to scan the space **70**. In various constructions, the spacing between scanned points ranges from about a millimeter to about a meter, although larger, smaller, or intermediate spacings are also possible.

In practice, the security system **20** should be capable of distinguishing actual security threats from so-called 'false positives,' i.e., objects **80** that move within the space **70** but which are not intruders. False positives may include pets (e.g., cats or dogs) as well as balloons, plants, or artwork (e.g., mobiles) that may move due to movement of air in the space **70**. In outdoor use, the system **20** should distinguish movement of small animals (e.g., raccoons, squirrels) from actual security threats that are posed by humans or other large objects.

Therefore, the system **20** performs subsequent analysis of the scan data. Using data collected from each scan, the system **20** produces a three-dimensional map of reflective features in the space **70**. Analysis is then performed on two or more of the maps to determine if there are security threats in the space **70**. In one construction, an initial 'baseline' three-dimensional image is collected at a given time, e.g., when the system **20** is initially armed. All subsequent images are then compared relative to this baseline image. In another construction, a comparison is performed between images collected at subsequent time points, to determine changes that occur from one time point to the next.

The comparison may comprise a map showing point-by-point differences between the two compared images (i.e., a difference map is generated). Any substantial change from either the baseline map or from the map of the previous time point would be further investigated as a possible security threat. Maps of differences between the pairs of images may be further analyzed to extract individual features, e.g., based on aspects such as the size, shape, or height of the object.

Alternatively, the system **20** may analyze each three-dimensional map to extract features and identify individual objects **80** within the space **70** (e.g., based on criteria such as the morphology of the object **80** and/or whether it is moving) and subsequently track the locations of the identified objects **80** over time. Thus, the information gained from extraction and tracking of features is used to distinguish false positives from actual threats, and any object **80** that meets predetermined criteria for a false positive are ignored.

For example, items such as balloons or plants might move slowly within the same approximate area (e.g., due to air flow within the space **70**) and thus over time the movement of the objects **80** would be restricted to within the same limited area. Similarly, the tracking of objects also allows analysis of potential threats based on the rate of movement of the objects. False positives such as plants or balloons can be distinguished from actual threats (e.g., a human walking through the space **70**) based on differences in the rates of movement of the different types of objects. In addition, the analysis of potential threats can combine predictive information from several different types of analyses to more effectively identify actual security threats.

Other types of false positive objects that might be encountered in a residential setting include pets. Among the possible strategies to exclude pets as actual security threats is to determine the height of any object that is moving, relative to the surface on which the object is moving. For example, if the moving object is on the floor of the space **70**, the height of the object is determined relative to the floor. Alternatively, if the moving object is on another surface (e.g. a table or sofa) the height of the object is determined relative to the other surface. Thus, even if the pet climbs onto another object, it will still be properly recognized as a false positive, i.e., not an actual security threat.

Another type of security threat that the system **20** may identify is an attempt to block operation of the system **20**. Specifically, an intruder might cover the transmitter **30** or one or both of the detectors **40**. If the system **20** fails to receive any reflected energy from a complete scan of the space **70** on one or both detectors **40**, or if the readings from one or both detectors **40** indicate the presence of an object that is very close to the transmitter **30** and/or detectors **40** (e.g., according to a predetermined criteria such as less than 0.5 meters), then the system **20** determines that a potential threat has been identified and initiates an alarm, as discussed below.

When an actual security threat has been identified, the system **20** activates and alarm and/or notifies a remote location of the threat. The alarm may include activation of lights (e.g., floodlights, flashing lights, etc.), sounds (e.g., mechanical or electronic bells or sirens), or other devices (e.g., doors may automatically close and/or lock). Additionally, the system **20** may notify a remote location of the security threat, including a police station, private security firm, or an individual (e.g. through a pager, cell phone, or other portable electronic device, an automatically-generated email, or other electronic means).

Various features and embodiments of the invention are set forth in the following claims.

What is claimed is:

1. A method of distinguishing false positives from threats in a space, the method comprising:

(a) collecting a first scan of the space during a first time interval, comprising

(i) illuminating at least a portion of the space with an energy from an energy source such that the energy is reflected from a surface in the space;

(ii) detecting the incident angle of the reflected energy with a plurality of detectors, each disposed at a known distance from the energy source;

(iii) calculating a distance from the surface to the energy source using triangulation and the incident angle detected by each of the plurality of detectors and distances between the plurality of detectors;

(iv) repeating steps (i)-(iii) for a plurality of portions of the space;

(v) generating a first three-dimensional map of the space for the first time interval;

(b) collecting a second scan of the space during a second time interval, comprising repeating steps (a)(i)-(a)(v) above during the second time interval to generate a second three-dimensional map of the space;

(c) comparing the first three-dimensional map to the second three-dimensional map to determine a change in the space;

(d) identifying a potential security threat based on the change in the space; and

(e) determining, based on the change in the space, if the potential security threat is a false positive based on a rate of movement, a height, and a location of the threat within the space.

2. The method of claim **1**, wherein illuminating at least a portion of the space with energy from an energy source includes illuminating with a light source.

3. The method of claim **2**, wherein illuminating with a light source includes illuminating with a laser.

4. The method of claim **3**, wherein illuminating with a laser includes emitting a beam having a modulated signature.

5. The method of claim **1**, wherein illuminating at least a portion of the space includes illuminating a room.

6. The method of claim **5**, wherein illuminating a room include illuminating with a laser.

7. The method of claim **6**, further comprising attaching each of the plurality of detectors and the laser to a ceiling of the room such that the laser is between the plurality of detectors.

8. A scanning security system, comprising:

a transmitter comprising an energy source and a scanning assembly;

a plurality of detectors, each configured to detect a direction of energy impinging thereon;

a computing system including a processor and a storage medium, the computing system configured to

(a) cause a first scan of a space during a first time interval, wherein the first scan includes

(i) illuminating at least a portion of the space with energy from the energy source at an illumination angle, such that the energy is reflected from a surface in the space;

(ii) detecting an incident angle of the reflected energy with each detector disposed at a known distance from the energy source;

(iii) calculating a distance from the surface to the energy source using triangulation based on the incident angle detected by each of the plurality of detectors and distances between the plurality of detectors;

(iv) repeating steps (i)-(iii) for a plurality of different locations in the space;

(v) generating a first three-dimensional map of the space for the first time interval;

(b) cause a second scan of the space at a second time interval, wherein the second scan includes repeating steps (a)(i)-(a)(v) above during the second time interval to generate a second three-dimensional map of the space;

(c) compare the first three-dimensional map to the second three-dimensional map to determine a change in the space; and

(d) determine if a potential security threat is present based on the change in the space, and

(e) determine, based on the change in the space, if the potential security threat is a false positive based on a rate of movement, a height, and a location of the threat within the space.

9. The scanning security system of claim **8**, wherein the energy source comprises a laser.

10. The scanning security system of claim **9**, wherein the detector comprises a hemispherical element having a plurality of tubes attached thereto, wherein each tube has an energy detection element disposed therein.

11. The scanning security system of claim **9**, wherein the detector comprises an optical element focused on an array of detection elements.

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